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the independent newsletter of energy conservation, building science & construction practice

Inside . . .

Radiant heating systems have been around for thousands of years. Recently, new equipment on the market that allows for quick and easy installation has meant that radiant systems are being installed in more new homes. Ken Farrish reviews the basics of radiant systems. We also review the basics of thermal comfort.

Dynamic Wall construction is an innovative approach to building energy efficient homes that can provide mechanical ventilation at a reasonable cost. We review the results of a demonstration project in Edmonton.

Air flows in buildings represent a challenge to proper construction and design. We present a couple of demonstrations that can be done by anyone to get a feel for these air flows.

How to control ventilation systems is a hot topic that is getting much attention. We report on the results of one demand controlled ventilation system that was monitored in Ottawa.

We also report on the new version of HOT2000, the latest from the TRC, new innovative products that may be on the market soon, optimum glass spacing in skylights, and much more.

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Radiant Heating

From the Publisher . . . . .

We are more aware than at any time in the past that the health, comfort and indoor air quality in a home depends on the materials that have gone into the building, the types of mechanical equipment and the way they are all put together.

To say that the ''House is a System'' is not just a buzz phrase but is very descriptive of how all the parts of a house work together. In Canada we have been world leaders in identifying the concept and letting the building industry know the facts. Through activities such as the R-2000 Program extensive monitoring has been done to prove that a well built house is safe and healthy, more so than conventionally built older homes.

The hope has always been that the industry will do what has to be done correctly so that regulations don't have to introduced to cover everything. In theory that sounds good but it doesn't always get put into practice, which is why we end up with many regulations, and in fact we may even need more.

This was brought home to me in a recent example in Vancouver. A very high profile demonstration house was built and as a major sponsor was the gas utility, all appliances including stoves were gas fired. However, the gas ranges were not vented (the fan over the stove was a recirculating unit).

While natural gas is a clean burning fuel, we know that carbon dioxide, nitrous oxides and water vapour are given off which is why they should be vented. However, there are no requirements to vent gas stoves!

In the case of gas furnaces and fireplaces, we take special precautions (and they're legislated) to ensure that proper venting is provided. Yet the amount of gas used by the stove matches the gas fireplace and we know the stove will be used every day while the fireplace is used only occasionally.

In an R-2000 home such a thing would not have been allowed as all fuel burning appliances must be vented. Unfortunately, the demonstration house was not R-2000.

The most distressing aspect was that many of the Gas utility's representatives present at the opening were not concerned nor were they aware that an unvented stove would be a problem.

We obviously still have a long way to go!

Richard Kadulski
Publisher

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Radiant Heating

by Ken Farrish

Radiant heating is often called the most comfortable type of heating system. Radiant heating installations for room heating (ie: where the heat source is in the surrounding surfaces themselves) were known and highly valued in ancient times.

Ancient cliff dwellings were designed to allow the sun to radiate in through window openings and onto the stone floors which absorbed the heat and re-radiated it back into the room. In early Roman times the baths were designed with underfloor ducts which carried warm air that warmed the floors which in turn radiated heat into the room.

Old Korean earth homes were designed with ducts in the ceiling which carried the heat from their fires and warmed the mass of the structure that in turn re-radiated back into the living areas.

Central masonry stoves were designed with chambers through which the exhaust heat and smoke would pass. The mass would absorb the heat and re-radiate it into the room.

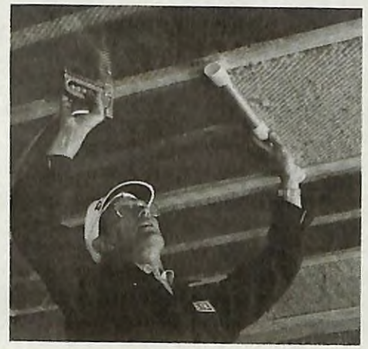
By the 1940's hydronic radiant systems became quite popular in some areas. Most were hot water in the floor using copper pipe embedded in concrete. By the 1950's problems arose when the copper pipe started to corrode and many systems leaked and caused water damage. This caused the demise of radiant heating for over 20 years.

In recent years incredible advances have been made in the types and quality of radiant heating systems and are now used to heat all kinds of buildings from airport hangars to bathrooms.

The development of resistance electric cable heating allowed for placement of these cables in concrete and plaster to provide radiant heating in the floor or the ceiling. New plastic pipe material has improved the confidence in hydronic systems.

This must be why in spite of overpriced systems, bad installations and frequent service problems, radiant heating is increasing it's market share in Western Canada. Some claims are that some form of radiant heating is used in up to 20% of new homes either as primary heating, supplementary heating, zone heating or floor warming.

Most purchasers decide on radiant heating because of it's reputation as a comfortable heating system. What people don't



realize is the wide range of products along with the varying opinions (usually from poorly informed and biased sales people) as to which one is the most appropriate for their use.

System Types

Radiant heating systems can be classified into three types, based on their operating temperatures:

- high intensity ceiling
- medium intensity ceiling
- low intensity (ceiling or floor)

High Intensity

High intensity systems operate at temperatures as high as several hundred degrees C.. They are used only in overhead applications in larger, non-residential buildings such as factories, warehouses or garages.

These heaters are usually small in size and tubular in shape with either a combustion or ceramic burner. The heat from a small source at a high temperature is radiated over a large area.

Medium Intensity Systems

Medium intensity radiant heating systems operate at medium temperatures (to 250°F). As with the high intensity systems, they are used only in ceiling applications, mostly in commercial or institutional buildings although they can be used in some high-ceiling, residential situations.

Most of these heaters are assembled as a complete units into a T-bar ceiling or attached directly to the ceiling surface. They may be electric resistance heating elements placed in an enclosure with an insulated backing. The surface of the heating unit is usually painted with a special heat resistant, rough coating which looks similar to ceiling tiles.

These systems heat from a larger surface area than the high intensity systems but at much lower temperatures. When heat is called for, the element heats up and the coated surface in turn radiates the heat into the room.

Low Intensity

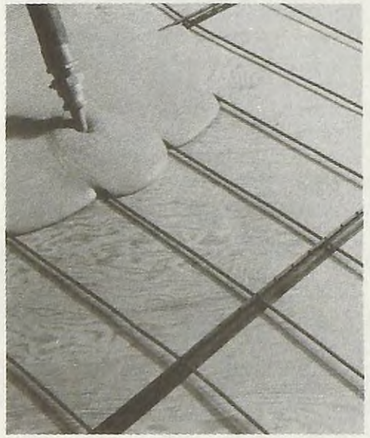
Low intensity radiant systems operate at temperatures of 90-130°F. Due to their lower output they can be used in either ceiling or floor applications and may use circulating hot water or electric resistance elements to create the radiant heat. These are the most commonly used systems in residential applications.

They are usually placed behind the ceiling or below the flooring and they heat up these surfaces which in turn radiate heat into the room.

Ceiling Systems

The most common ceiling systems are foil panels which come either fully assembled from the factory or in rolls that are cut and assembled on site. These are resistance elements made of foil or carbon encased in a protective plastic covering or resistance electric wire embedded in a mass (such as drywall). In all cases the panels are wired up to the building's electrical system and controlled by individual room thermostats.

System design should be based on the appropriate number of panels to cover the calculated room heat load. The panels are laid out strategically to cover the areas of higher heat loss (near windows) while being distributed evenly throughout the room. The type and thickness of the ceiling finish may place some limitations on the amount of heat delivered to the room. They operate at temperatures of up to 85°F, and have a heat output of 35 - 100 BTU/Sq.Ft. (10 - 30 W/Sq.Ft.).



Floor Systems

Similar to the ceiling systems these heat up a mass, in this case the floor, which in turn radiates the heat into the room. These can be designed to fit into any type of building but the heat output is limited as the maximum floor surface temperature is about 85° F (30°C). This is considered to be the maximum temperature for human comfort when feet are in contact with a heated surface.

All hot water floor heating systems function by embedding piping in the mass of the floor. The most common installations are pipes in a concrete slab or on top of the wood floor with a thermal mass (concrete) poured on top of them. Some systems use pipes below the wood flooring but these are difficult to design due to the insulating properties of the wood.

The system design takes into account calculated heat loss. Heat output is determined by pipe spacing, water temperature and flow rate. The type of floor covering, it's thickness and insulating value must also be considered. Each zone is control led by a thermostat and when the room calls for heat the boiler heats the water which is pumped through the pipes, warming the mass of the floor which then radiates the heat into the room.

Electric floor systems are similar to water floor systems in that they place the heat in the mass of the floor which in turn radiates heat into the room. The maximum operating temperature is 85 °F. Heat output is about 35 BTU/Sq.Ft. (10 Watts/ Sq.Ft.)

Nuheat is the only system which does not require a mass because it can be installed directly below the carpet. Uses can include primary heating, supplementary heating, zone heating or floor warming.

The heating units are placed in/on the floor and wired up to a thermostat which is connected to the main electrical panel. Since it is considered unitary heating, each room must have it's own thermostat.

Radiant Heating Theory

How does radiant heating work?

Simply put, it is heat that moves from a warm object to a cold object via radiation. Radiation is the movement of heat by invisible, electromagnetic waves from one object to another. Any object will radiate heat to another with a lower temperature (ie: Sunlight radiating through space to warm the earth).

Radiant heating systems warm up the ceiling or floor to a temperature that is higher than the rest of the room so the heat radiates into the room, onto those cooler surfaces. By choosing the system which will operate at the proper temperature (intensity) you can heat many different buildings with various kinds of radiant heating.

In residential applications the production of infrared radiation requires that at least one surface of the room be warmer than the others. This allows the emittance of heat to the other surfaces.

Whether the hotter surface is the floor, walls or ceiling does not matter from the standpoint of radiation capability but it does matter from the standpoint of comfort. The ceiling and the floor are the most practical since the heat can then be distributed from the largest surface area available.

There are many different methods of providing heat from the floor or ceiling but virtually all of them function by being placed behind the actual surface materials. They then heat up these surface materials which in turn give off the heat into the room through infrared radiation.

One of the most significant benefits of these radiant heating systems is the comfort provided from this constant, even, low temperature warmth given off from such a large surface in the room.

Radiant Heating Systems and Human Comfort

Space heating is in reality a cooling problem. Our bodies always produce heat and must be cooled to remain comfortable. The purpose of a space heating system is to provide an environment which gives the body an opportunity to shed heat in a balanced, healthy and comfortable way.

We shed heat in several ways, the most important of which are convection and radiation and to a lesser extent evaporation. The sum of the body heat losses by each should at all times correspond to the amount of heat produced by the body if the body temperature is to remain stable.

Total body heat will be constant during a given activity, but the balance between the two may vary. For example if convection is increased by lowering the air temperature, the radiation proportion must be reduced by increasing the temperature of the surrounding surfaces (mean radiant temperature).

A simple formula has been developed that allows normal comfort level of a room to be calculated by adding the two primary heating components: air temperature and mean radiant temperature (average room surface temperature). The formula is: Air temperature (T_{air}) + mean radiant temperature (TMR) = 140.

For example, with a conventional forced warm air heating system we maintain an air temperature of about 72°F (22°C) with a mean radiant temperature of 68°F (72 + 68 = 140). With a radiant heating system comfort is achieved at 68°F air temperature if the mean radiant temperature is 72°F (68 + 72 = 140).

The fact that the air temperature in a room is 68°F or 72°F is no guarantee of comfort. A room with a temperature of 68°F (20°C) may feel warmer than a room in which the air temperature is 72°F if the radiant losses are balanced.

The human body is more comfortable when most of its heat is shed by convection rather than by radiation. Thus low air temperature is necessary in order to allow sufficient cooling by convection.

Radiant heating systems can easily maintain these ideal conditions in a room.

Factors Affecting Comfort

Air Temperature

The air temperature required for comfort depends on air movement, kind and level of physical activity, type of clothing worn, age and the amount of thermal radiation from the exterior surfaces. People seated in a room are generally comfortable at 70°F; if there are large glass areas 74°F. Where people are physically active (as in a gym) then 50°F may be enough. Residential heating systems are normally designed on the basis of providing indoor temperatures of 72°F.

Temperature of the Room Surfaces

The amount of body heat lost by radiation depends on the surface temperatures of the room. When the surface temperatures of a room are increased the air temperatures can be lowered without causing discomfort. When the surface temperatures are lowered the air temperatures must be increased to balance the additional radiative heat loss.

Air Temperature Swings

Most people do not notice temperature changes of less than 2°F or a rate of change in temperature of less than 4°F per hour. Temperature stratification (vertically) between head and ankle height should be less than 5°F (3°C).

Air Movement

Moving air determines convective and evaporative heat losses. Proper control (not too much air motion) is important where people are at rest, where cold air is introduced or where there will be older people or others sensitive to drafts. An air velocity of fifteen feet per minute is the recommended maximum. The neck and ankles are the most sensitive body parts.

Humidity

The effect of humidity on comfort is more pronounced where the temperatures are high (that is, where body cooling is required); or where people enter a conditioned space. Relative humidity levels of 40% to 60% provide good comfort and health conditions.

Fresh Air Requirements

Fresh outside air is required to supply the oxygen consumed by the body, avoid undesirable carbon dioxide concentrations and remove objectionable odours.

Ventilation can be incorporated into forced warm air heating systems. It must be designed separately for radiant heating. Specific levels of ventilation are now required by many building codes.

Minnesota Cold Climate Housing Centre closes.

Since 1986 the Cold Climate Housing Centre has provided information and services to many building and housing professionals, mostly in Minnesota and the upper midwest region, but individuals throughout the U.S.A. have also been helped. Most programs have been tailored to professional builders and educators, but home owners have also been assisted on a regular basis.

One of the major activities was Winter Workshops for Building Professionals. This winter workshop series provided over 1,000 building professionals with the latest information on insulation, air-tightening, moisture control, ventilation, heating and cooling systems, and indoor air quality.

The Centre is being closed as the grant that created it in 1986 was exhausted this summer.

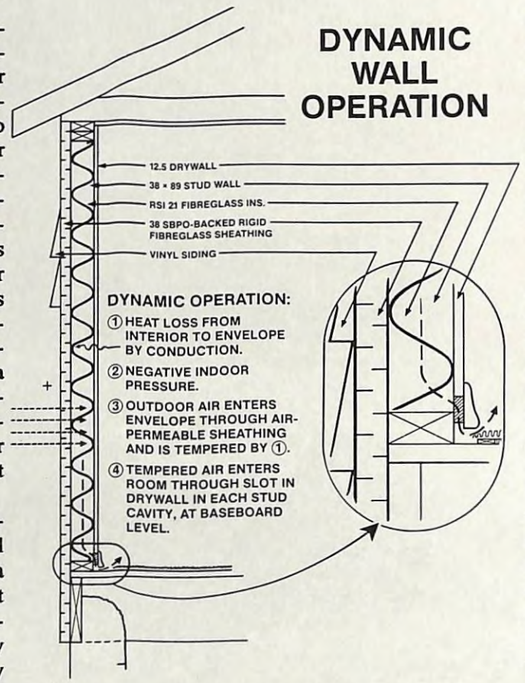
Dynamic Walls:
Demonstration project results

The building industry is under pressure to provide affordable energy-efficient housing without sacrificing quality. The recognition of indoor air pollution as a health hazard is increasing the pressure.

Improved airtightness has resulted in requirements for mechanically assisted combustion air systems and mechanical ventilation. Consumers are beginning to accept the higher costs of tighter building envelopes and the associated incremental costs for induced draft or direct vent gas appliances. In Alberta consumers are not readily accepting the higher costs of heat recovery ventilators nor the high operating costs resulting form mechanical ventilation without heat recovery. Thus a ventilation strategy that is effective, reliable, and relatively inexpensive is essential for consumer acceptance of an energy-efficient house.

The Dynamic Wall is a ventilation strategy that has the potential to meet these criteria. It is an idea first conceived in Sweden, but developed into a practical application of the theory in Canada by Dr. John Timusk at the University of Toronto. (see SOLPLAN REVIEW No. 14)

The construction details of a dynamic wall house ensure that the house is sufficiently airtight to direct incoming ventilation air through the "dynamic" portions of the envelope, sufficiently air-permeable to allow air to be brought in at very low velocity. The heat loss through the exterior wall by conduction warms the cooler air being brought in. It offers the potential to provide ventilation air with less chances for mechanical failure and without the costs associated with heat recovery ventilators.


DYNAMIC WALL OPERATION
12.5 DRYWALL
38 × 89 STUD WALL
RSI 21 FIBREGLASS INS.
38 SBPO-BACKED RIGID FIBREGLASS SHEATHING
VINYL SIDING
DYNAMIC OPERATION:
① HEAT LOSS FROM INTERIOR TO ENVELOPE BY CONDUCTION.
② NEGATIVE INDOOR PRESSURE.
③ OUTDOOR AIR ENTERS ENVELOPE THROUGH AIR-PERMEABLE SHEATHING AND IS TEMPERED BY ①.
④ TEMPERED AIR ENTERS ROOM THROUGH SLOT IN DRYWALL IN EACH STUD CAVITY, AT BASEBOARD LEVEL.

Alberta Demonstration House

A demonstration house in Sherwood Park, Alberta was built by Lincolnberg Homes in the winter of 1988-89 to test the dynamic wall concept, to determine if the dynamic wall system works according to theory and can be used in production housing. It also was to see if the home owner would benefit in terms of space heating, air quality and comfort. The house was monitored by Will Mayhew of Howell Mayhew Engineering using an extensive computerized monitoring system during the 1989-90 heating season.

Specifically, the objectives of the project were:

- to demonstrate and assess the construction methods;
- to determine the cost-effectiveness of the concept in Alberta;
- to analyze the operation of the dynamic wall system; and
- to determine how other components and systems in the house interact with the dynamic wall.

The house is a typical four-bedroom, two-storey tract house with an attached two-car garage. It generally conforms to conventional wood-frame practices with the following exceptions:

- Glasclad sheathing in place of standard 10 mm spruce plywood
- Non-naturally-aspirated gas-fired appliances were installed
- A central exhaust-only mechanical ventilation system was installed.
- ADA techniques that were employed eliminated the potential for short-circuiting of the dynamic wall.

Exterior wall construction included vinyl siding, TYVEK backed rigid fibreglass sheathing (GLASCLAD), fibreglass batt insulation, and ½'' drywall. Small holes at the base of the wall (behind the baseboard) allow the air into the house. The way the dynamic wall works is illustrated in the detail.

The house was built air-tight. Blower door test results indicated an air change rate of 0.93 ACH before the ½'' dynamic air inlet holes were drilled in the interior drywall (with the dynamic holes it was 1.31 ACH). Ten months after completion it was still tight - 1.57 ACH. The loosening was due to a combination of ambient test conditions and airtightness deterioration.

The mechanical system was designed to operate a dynamic (negative pressure) mode.

The incremental cost of building the demonstration house was about $4,200.00 more than a conventional house of similar size. Annual energy cost savings were estimated to be $370.00.

Dynamic wall operation

Dynamic wall operation depends on pressure and temperature differences between inside and outside as well as wind speed and wind direction. The degree of tempering (the heat gain) of dynamic air was found to be about 74% of the indoor-outdoor temperature difference. The temperature of incoming air was notably affected by solar radiation.

An exhaust-only mechanical ventilation system with non-naturally-aspirated gas appliances not affected by negative pressures are required for operation in the dynamic mode.

What was found

Measurements indicated that about 30% of total ventilation air was entering through the dynamic system air inlets. At a total ventilation flow of 137 cfm, the pressure drop across the building envelope was about 5 Pa and the flow through the dynamic air holes around 48 cfm .

In windy conditions, significant increases in flow developed on the windward side of the house. The combined wind and stack effects were not enough to reverse flow through leeward dynamic holes upstairs but there was a definite wind effect on the flow through individual walls.

Ventilation air was well distributed throughout the house, but it relied on the forced warm air heating system to mix ventilation air with return air, thus being capable of providing approximately 37 cfm of continuous ventilation per occupant (based on four occupants). There was effective distribution of ventilation air without any additional ductwork.

Because of the action of negative pressure, the dynamic wall eliminates the potential for wall moisture problems as moist indoor air is not able to penetrate the construction.

No discomfort was caused by cold drafts or cold wall radiation when the house was operating in the dynamic mode. However, when operation was in the static mode (no dynamic air) with the fresh air and combustion air ducts open as in conventional housing, the home owner commented that the house felt cooler. Surface temperatures dropped 1°C with the temperature stabilizing approximately 10 minutes after the switch from static mode.

The temperature of the dynamic air entering the house varied with the indoor-outdoor temperature differential. It is also a way to collect significant amounts of solar energy at no additional cost. When daytime temperatures were -18°C, the solar radiation heating the south wall raised the temperature of the dynamic air entering the house by more than 5°C.

The belief persists that negative pressure within the building envelope could encourage the entry of radon to the living space. Although Alberta is not considered a high-risk area for radon, the house was checked. A radon sampling pump located at one of the dynamic air inlets was also used to monitor the presence of glass fibre particulates. Six small fibres were detected. (No standards for glass fibre concentrations have been set for residential occupancies).

No significant levels of indoor air pollutants were measured (Formaldehyde levels were very low). The occupants found the dynamic house comfortable to live in.

The dynamic wall concept was found to be both achievable and, in spite of the uncontrollable variables, is workable in Alberta. Exterior sheathing was roughly one-half of the incremental cost so cost savings could be realized if cheaper sheathing materials are identified. Reductions may also be possible by simplifying the mechanical system and the way dynamic air enters the house.

The findings suggest that operating at 0.3 ACH, adequate quantities of ventilation air are being delivered and distributed throughout the house.

Another aspect of the dynamic wall is that it may allow the use of relatively thin walls. This will provide more usable space, as decreasing the wall thickness in a 2,000 sq. ft. house by one inch can increase the net floor area by some 20 sq. ft.

Dynamic Wall Demonstration Project, undertaken with funding under the Innovative Housing Grants Program of Alberta Municipal Affairs, Edmonton. L. Nakatsui (Lincolnberg Homes) and W. Mayhew (Howell Mayhew Engineering), Edmonton, Alberta.

Letter to the Editor

Sir,

I recently subscribed to your publication and have found the last two issues to be informative. I was surprised to see in the Job-Site Innovator items a commendation given to a Nova Scotia builder for the laminated header. What he has come up with (to his credit) is a section of a structural foam-core panel. These have been around for many years (in the form of walk-in coolers and freezers) and are now widely accepted for their energy efficiency, strength and ease of construction in residential, commercial and industrial buildings.

There is at least one manufacturer of structural panels in Canada (using an EPS core): Thermapan Industries in Ontario. If the idea of the laminated header is attractive, the next logical step is to build the entire structure of panels. I might add that the panels are also the most efficient air barrier and vapour retarder of any building system I have seen.

Chris Norman
South Gillies, ON

Air Flows in Buildings

For the past several years an international task force has been researching how air flows in buildings. The objectives of the work are to study the airflow patterns (they can be tricky) so that design tools that estimate flows are acceptable and accurate. The work was a part of the International Energy Agency (IEA) energy conservation in buildings program.

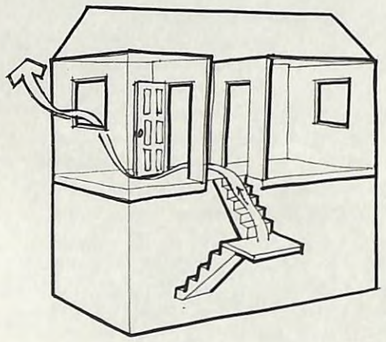


Fig. 1

A couple of do-it-yourself experiments that can be done by anyone point out a way that ventilation flows can be detected without resorting to expensive monitoring equipment. These are conditions we all have observed at some time without necessarily paying attention to them. They were described by one of the principal researchers, Dr Koos van der Maas from Switzerland.

Feel the Stack effect

The stack effect in a multi-storey building can be spotted. In early fall overheating can happen, especially if blinds or shades are not closed. As the sun shines in, the inside can get uncomfortably warm even if outdoor temperatures are low. Opening the window will not lower the temperature. Instead of cool outside air coming in, the warm interior air flows through the door and leaves through the window. (see Fig. 1)

If the door in the room is closed, and the door is fairly snug in its frame, then the outside air has a better chance of entering and leaving through the same window (see Fig. 2).

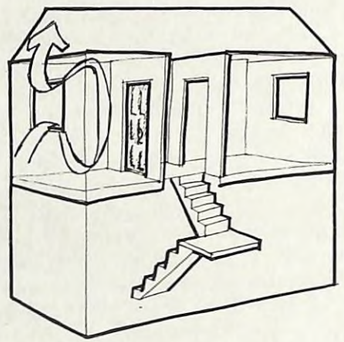
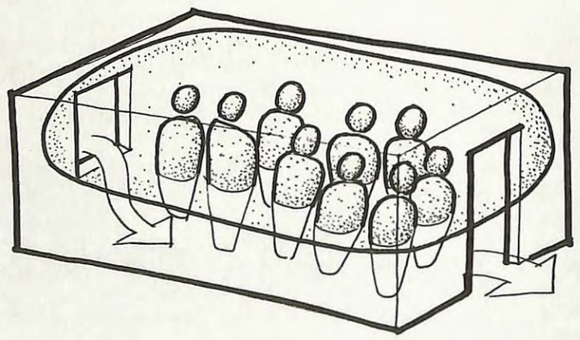


Fig. 2

Smell the Neutral Pressure Plane

The neutral pressure plane is an imaginary plane that divides the areas of positive from negative pressure in a house. It is constantly fluctuating, depending on wind and temperatures. Above the neutral pressure plane, the building is positively pressurized, so it tries to leave the building; below the neutral pressure plane the building is at negative pressures, so outside air is drawn in. This is why cold drafts (infiltration) are normally felt in the lowest portions of the house.



It is actually possible to determine where the neutral pressure plane is by smell. Think of a packed room at a party. There are windows but while they may be open, they are covered by curtains. The temperature rises to the point where it gets hot and sweaty. The air quality deteriorates so to induce cross-ventilation doors and windows are opened, but the curtains still cover the windows. At the open door you expect to find the best air quality, only to find the air smell as bad as in the room itself. If you crouch down, you'd discover somewhere near the middle of the door height the existence of a level below which the smell was gone and the is fresh. It's why our feet will feel a draft even though it's still hot inside.

The do-it-yourself experiments were described by Dr. Koos van der Maas, EPFL-Lausannne, in "Flow Flash 5", July 1991, the newsletter of IEA Annex 20: Air Flow Patterns within Buildings.

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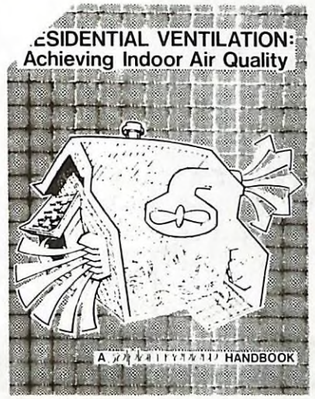

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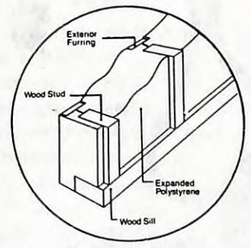

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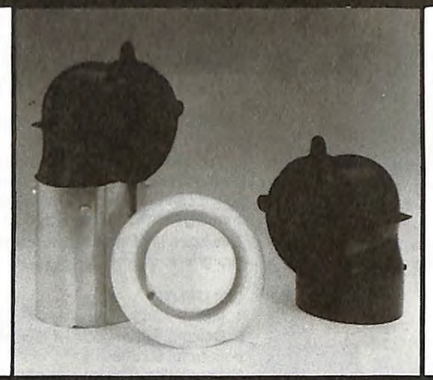

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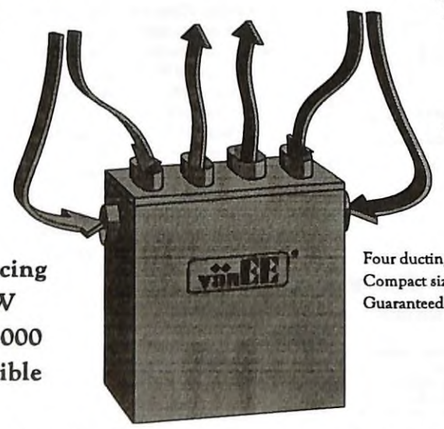

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HOT 2000

WHAT IS IT?

HOT2000 is an advanced approach to the design and modelling of energy efficient structures.

HOT2000 is an easy-to-use computer program designed to assist builders, architects and engineers design low-rise residential buildings. Utilizing current heat loss/gain and system performance models, the program aids in the simulation and design of buildings for thermal effectiveness, passive solar heating and the operation and performance of heating and cooling systems.

WHAT CAN IT DO FOR ME?

HOT2000 lets you input comprehensive data on proposed building design, analyze the expected heat loss/gain, and revise and test altered designs until a satisfactory design is achieved.

Contains extensive weather data, several models for HRV, foundation, water heating systems and more.

HOW TO GET HOT2000

HOT2000 is available from the Canadian Home Builders Association (CHBA) in either a Canadian or U.S. version at the following prices:

* $120.00 (Cdn) for the Canadian version
* $150.00 (US) for the USA version (contains US weather data)

Price includes User and Reference Manuals
Canadian residents: please add 7% GST

To order HOT2000, complete the attached form and send it with a cheque or money order to:

HOT2000 Sales
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The Canada Centre for Mineral and Energy Technology (CANMET) is the research and development arm of Energy, Mines and Resources. EMR/CANMET's Buildings Group works with industry to develop and commercialize the technologies to make Canadian houses more energy efficient. With the support of the Buildings Group, Solplan Review presents this information on some current CANMET projects. For more information contact: Energy Efficiency Division, EMR/CANMET, 580 Booth St., Ottawa, K1A 0E4.

Demand Controlled Ventilation Systems

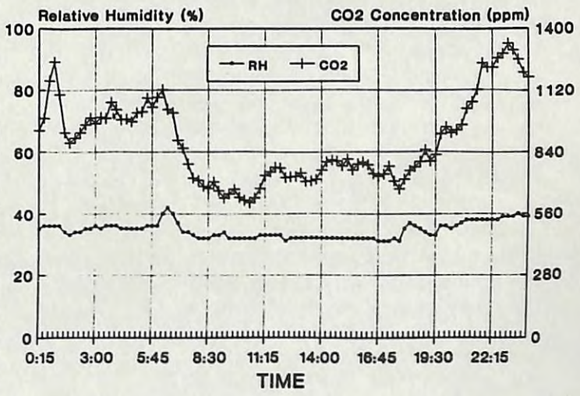
As houses have become more air-tight, the need for effective mechanical ventilation systems has increased. These systems must introduce fresh air, exhaust stale air and be as energy-efficient as the houses they serve. Demand controlled ventilation systems (DCV's) which provide mechanical ventilation only when ventilation is needed appear to meet all of those requirements.

Recently the Buildings Group, in conjunction with Scanada Consultants Ltd., field tested a DCV in two houses. The DCV consisted of mechanical air extractor units (exhaust fans) and passive air inlet units. The extractor units ran 24 hours a day at slow speed maintaining a slight negative pressure across the building. The passive air inlets were equipped with humidity sensors composed of nylon strips which respond to changes in humidity by shrinking or stretching. These movements, in turn, cause a moveable shutter to open or close.

The field tests sought to determine two things: the effectiveness of humidity as the controlling factor in determining ventilation rates and the effectiveness of the air inlets.

This humidity controlled ventilation system relies on humidity levels generated by occupants, either by their activity levels or by the utilization of the space for laundry, cooking, bathing, etc. When relative humidity is a room is high, the mechanical extractor unit exhausts stale air from that room at a greater rate and the air inlets increase the introduction of fresh air. Conversely, when the relative humidity is lowered air flow into and out of the room is lowered proportionately.

In both houses tested, analysis of the exhaust system showed that continuous air flow was maintained adequately by the extractors. However, the air inlets failed to respond adequately under two different scenarios. At normal occupancy levels the air inlets did not respond instantly to small increases in room humidity. While the inlets responded well to a large increase in room humidity as may be caused by a several people entering the area, the air flow was not enough to quickly offset the higher CO_2 levels.



Relative Humidity and CO_2 levels in the bedroom compared to occupancy over a 24 hour period. Relative Humidity is fairly constant while CO_2 varies with occupancy.

As a result, the study team found relative humidity to be a poor indicator of occupancy. Their report notes "response times are slow and often there are no discernible changes in relative humidity despite major changes in occupancy and CO_2 concentrations."

On a more positive note the field test did find that carbon dioxide levels appear to track human presence and activity very well and that a demand-controlled ventilation strategy with CO_2 as the factor determining the rate of ventilation - perhaps in combination with indoor relative humidity - might provide good air quality and moisture control in cold climate houses.

*To obtain a copy of the report (**Operating Characteristics and Performance of A Humidity-Controlled Ventilation System, Phase II: Monitoring and Performance Analysis**) or for more information contact the Buildings Group, CANMET, Energy Mines and Resources, 580 Booth St., Ottawa, Ont. K1A 0E4*

Advanced Houses Program Response is Overwhelming

31 building teams, representing all provinces responded to CANMET's call for Advanced Houses Program proposals. The proposals are now being reviewed. Winners should be announced on November 12, 1991.

The Buildings Group: What is it?

The Buildings Group is the CANMET division responsible for researching and developing new ideas and technologies important to the building industry. It formed in 1989 to help make buildings more energy efficient while minimizing their environmental impact.

The Buildings Group works with all aspects of building and building science - from basic research, technical development, product assessment to standards development and technology transfer. The Buildings Group has achieved some notable successes, including the Brampton Advanced House which uses less than one-quarter of the energy of conventional housing. Some of the Group's recent initiatives include:

Advanced Houses Program

The success of the Brampton Advanced House has prompted the Buildings Group to take the program country-wide. Once built, these houses will field test various new ideas and product prototypes to establish a new state-of-the-art for residential construction.

HOT2000

The Buildings Group is the driving force behind the ongoing development of HOT2000, a computer program which simulates the thermal performance of residential buildings while they are still on the drawing board. Version 6, which calculates air conditioning loads and provides data on the new window technology, is now available.

Advanced Window Technology

The Buildings Group is working to strengthen the weakest link in the thermal envelope: windows. It sponsors basic research to develop new testing procedures, encourages development of new technologies and has helped create a new CSA standard method to calculate window energy ratings.

C-2000

Building on the success of the R-2000 Program, the Buildings Group is launching C-2000, which brings the same principles and approach in energy efficient construction to the commercial sector. Program planning seminars are now under way with relevant industry players in major centres across the country.

Research and development are only part of the Group's activities. For example, it is also working with CHBA's Technical Research Committee and the NRC on the new Energy Code for Buildings and also works cooperatively with organizations such as CMHC. It also identifies research needs and funds specific research projects through agencies such as ORTECH, CMHC, SRC and private consultants.

In coming issues, we'll take a look at other sections of CANMET that should be of interest to buildings and the building community, beginning with the Combustion and Carbonization Research Laboratory.

Updated HOT2000 Version 6 Hits the Street!

HOT2000 is a computer program that was developed by EMR for the R-2000 program. It is a tool to help builders, engineers and architects design and simulate the performance of residential buildings for energy efficiency, passive solar heating and the operation and performance of heating and cooling systems. More importantly HOT2000 is a tool that offers the designer and builder the chance to play the "what-if" game, looking at alternative construction options that may save money by optimizing the design.

Many changes have been made since the program first appeared to reflect monitored data and to respond to user concerns. The latest version (No. 6) has just been released by CANMET. HOT2000 just keeps getting bigger and better, but regular HOT2000 users will still recognize the new version. Unfortunately files from earlier versions are not compatible with Version 6.

What's new and improved?

There are many new features, some are subtle, others more significant. The major changes are new ways to enter data, an air conditioning module to calculate cooling loads, and window entries that take into account changes in window technology. It is also possible to rotate the house without changing other entries.

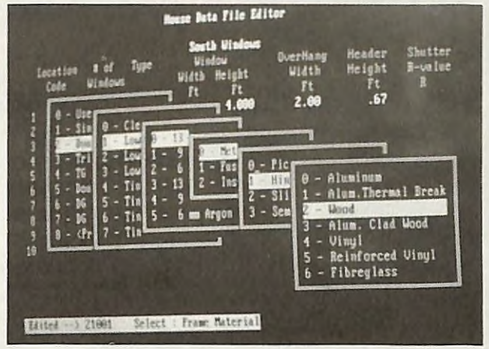
Cooling Loads

Even in a cold climate like Canada, where heating concerns dominate, sometimes you need to introduce cooling to maintain comfort. Cooling calculations are a new part of the program. Three types of air conditioning systems can be specified: conventional, ventilation and economizer modes (with dry bulb or enthalpy control). Calculations for sizing the air conditioning system include defaults if user values have not been selected.

Windows

Window data entries are more complex as eight directions are modelled and overhang data in all directions is used to estimate solar shading. The window entries take into account the latest information on window properties. Effective overall R-value and solar heat gain coefficients are calculated from inputs that indicate glass type, gas fill, window type (e.g. slider, awning or fixed), spacer type and frame material. Rough opening dimensions (window width and height) are entered for each window - the software makes the adjustment for frame size.

As all windows are entered with overhang data, it is now possible to rotate the house by any 45° increment. This makes it easier to use as a design tool (to calculate the impact of solar gains on the house performance) if orientation of the house is flexible.



Data entry made easier

Many of the options are presented in pull-down menus and a mouse or keyboard may be used for moving through the program (both IBM and MacIntosh versions are available). When activated, a box containing the possible options is displayed on the screen. A selection is made by highlighting the desired answer. For example, the six-digit code used to define window type is developed from a series of pull-down lists which select glass type, coating, gas fill, window type, spacer, and frame material. This is done automatically as each one is selected.

Data entry has been made easier in the new version as the gross area is entered for each component, rather than net area as was the case in earlier versions. This makes it easier to use for design studies as the component areas may be changed quickly to investigate various alternatives. For example, when window sizes are changed, but not the overall exterior wall area, it is no longer necessary to make changes to the wall entries as well as the window entries as it is taken care of by the program.

Another new feature is that each of the data entries for doors and windows includes a location name for the main wall, ceiling, door or basement wall above-grade entries. A checking routine insures that all references are acceptable and all calculated net areas are greater than zero. The checking is also done as the data is edited so that the user is alerted to improper definitions at the earliest possible time.

All exterior building envelope components are considered. These include the ceiling, main walls, exposed floors, doors, windows (in eight orientations) and four types of basement (crawl space, slab on grade, shallow, and full depth). Each of the 25 possible components may have as many as 10 different entries. The non-window data entries consist of area and effective R-value.

Mechanical Systems

Forced mechanical ventilation may be specified for a heat recovery ventilator (HRV) and/or exhaust fans. The ventilation system can be sized to meet the requirements of the CSA F326 standard by specifying the number of rooms of each type to the program. HOT2000 checks to insure that either the total or the specified exhaust flow rates is sufficient to meet the standard.

The space heating systems can include a conventional heating system and a heat pump. Furnace type, fuel type, capacity, steady-state efficiency and pilot light energy consumption may be specified. Furnace calculations include the effects of part load losses, pilot light and fan energy and increased ventilation induced by the chimney during the on cycle.

Natural air infiltration is estimated using a theoretical model developed at the National Research Council that takes into account air tightness, average monthly wind speed and the effects of mechanical ventilation. If a furnace with a chimney has been specified, the infiltration during the furnace off-cycle is also estimated.

HOT2000 calculates the net heat load needed by the house after the internal gains have been taken into account. The difference is what must be provided by the space heating system and can be used to size the heating system. Monthly and annual energy costs can be calculated for each fuel type if the user has assigned rates. The fuel rates may be selected for each fuel type on a monthly basis to accommodate utilities whose billing rates vary monthly or seasonally.

HOT2000 also includes utilities for viewing and editing weather data and fuel costs. Reports may be viewed on screen, printed, or saved for later printing by either a built in or a separate print spooling utility.

Version 6 is an improvement on earlier versions. Those who have used earlier versions will like this one even more. Those who haven't used HOT2000 before should try using it as it is easier to use. Playing the "what-if" game can more than recover it's cost. However, if you are not going to use it fairly often, then it would still be more cost effective to go to a specialist who uses the program on a regular basis.

We hope that a new simplified version will be developed in the future to offer a reasonably accurate but simpler method that will not need the thorough take-offs needed to use the current version.

CHBA is the licensed distributor for HOT2000. Copies are available from CHBA for $225.

CHBA HOT2000 Sales
Suite 702 - 200 Elgin St.
Ottawa, Ont. K2P 1L5

Technical Research Committee News

Energy Building Code

As we mentioned in the last issue of SOLPLAN REVIEW, a new Energy Building Code is being developed based on the **Measures for Energy Conservation** a document first developed in the late 1970's by the National Research Council but largely ignored. The new document is being developed as a stand alone model code that may be adopted by the provinces.

At the moment many (but not all) provinces at least include minimum insulation requirements in the building code. The new proposed code will go much further. Significant features being discussed include full depth basement insulation and quality control measures. For example, mandatory airtightness requirements are being discussed. This would not automatically mean that every building must be tested, but that each would have to meet a certain level of airtightness.

The question becomes one of what level of airtightness? Or even does there have to be a legislated airtightness level? What comes to mind instantly is: are there enough blower doors and airtightness testers in the country to be able to deal with such a requirement?

If you have any thoughts or comments on such an Energy Building Code be sure to make your voice heard. Contact your local association's Technical Advisory Committee or the TRC directly. This is your chance to provide input on proposed new regulations before they are finalized.

Ventilation Position Paper

CHBA has developed a draft position paper on residential ventilation that will be circulated to the provincial home builders associations for comment before the end of November. This paper will be used as the basis of CHBA's presentations to the National Building Code review process (for the 1995 Code) and the Canadian Standards Association for possible revisions to the standard.

It is hoped that this will also provide guidance for further research of ventilation issues and be an important factor in the decision as to whether or not CSA F326 gets incorporated in the building code.

Items of special concern that have been identified include how to deal with make-up air (especially for fireplaces) and the distribution of fresh ventilation air.

Hot-2000 version 6

The latest version of HOT-2000 is now available (see review this issue). The most significant change is the addition of a module to calculate cooling loads and incorporation of the latest in window technology.

CHBA is the licensed distributor. Order forms will be available through the Provincial associations (or you can order direct from the TRC).

HOT-2000 version 5.06 will still be the principal tool for verifying compliance with the R-2000 performance standard although results calculated with Version 6 will also be accepted.

Environmental Product Directory

With the interest in environmental issues today it has been suggested that a building products directory of environmentally friendly or recycled products be developed. This kind of directory would help builders and designers identify environmentally friendly products and materials when making design decisions and could help steer away from questionable products that could cause problems in the future.

For example, did you know that there are already limits to the use of products containing CFC's in Canada? Canadian manufacturers already are phasing out the use of CFC's in products (such as foam insulations) but this is not the case in other countries. Some products imported from the USA do not meet these Canadian standards. However, as there are no formal tests or review procedures when products are imported, they can easily find their way on to the market. An environmental product directory would identify such concerns and indicate product specifications.

This project is still at the discussion stages. If you feel that this is a project to be pursued, that you could take advantage of such a directory, or have some thoughts about how it should be structured, then contact your local Technical Advisory Committee (or the TRC directly) and pass on your comments.

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector. Membership includes builder members and representatives from industry, standards and governments bodies with an interest in housing.
To contact the TRC:
Canadian Home Builders Association,
200 Elgin St. Suite 502,
Ottawa, Ont. K2P 1L5
Tel: (613) 230-3060

The Talking House

The talking House is an information project initiated by Jon Eakes of Interface Productions of Montreal. It is a tool to communicate complex features of modern construction to consumers and professionals using short computer based animations.

The animations are usually 30 seconds to 60 seconds in length and deal with a single aspect of housing that is effectively illustrated by animation. It is ideal for use as a continuous loop used in demonstration houses.

Animations play directly from a computer so all the problems of video tape are avoided, while the quality of image and the ease and reliability of playback is increased. The Animation Players (customized computers) run without supervision and can be operated by a simple timer, in a continuous loop or by the viewer pushing a button.

For example, the builder who wants to illustrate the benefits of draft proofing and mechanical ventilation can use a couple of animations that demonstrate basic principles. A demonstration at the Tendances show home in Longueuil, Quebec on display at the CHBA annual convention last spring highlighted construction details of the house, including acoustic wall construction in the duplex using these animations.

Any contractor member of the CHBA or the APCHQ may request the use of one or more Animation Players loaded with specific animations. A VHS tape summary of the animations currently in the data bank is available on loan as a catalogue.

The price of each animation only covers actual costs of loading the appropriate animation into an Animation Player, packing and shipping and includes consultation, scripting and animating. Users have to supply their own computer or TV sets. The price for a basic low resolution 30 second animation with single language sound track is around $500.

For more information contact
Jon Eakes at Interface Productions,
C.P. 387, Suc Delorimier, Montreal,
Quebec H2H 2N7 Tel: (514) 598-9988

Housing Technology Grants

The Housing Technology Incentives Program funded by CMHC provides assistance (and grants of up to $15,000) to Canadian companies to develop new ideas and products which can improve the quality or affordability to Canadian housing.

Several recent grants caught our attention. We look forward to seeing these ideas in the near future.

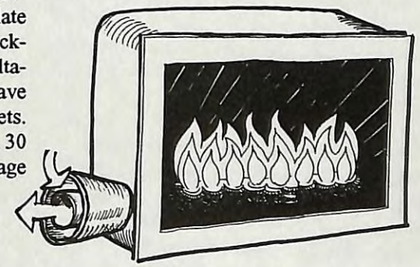
Enviroficient Products Inc. of Utterson, Ontario has been awarded a grant to design, develop and test a new wood stove that will burn wood efficiently while emitting low exhaust gas emissions.

Chromalox Inc. of Rexdale has been awarded a grant to design and develop a new system to pre-heat incoming ventilation air before it enters the return air plenum of residential furnaces. If cost effective, the pre-heater make it easier to meet the new ventilation requirements of the National Building Code.

American Water Co. of Kelowna, B.C. has received a grant for a new system for recovering heat from residential waste water ("grey water"). It will enable a prototype system to be installed and monitored.

Randor Development Corporation of Vancouver received a grant for the design, development and testing of a new water temperature and flow control valve for use with residential electronic faucets. The new valve is expected to provide automatic control of temperature and flow rates even when there is a water demand at other faucets. This invention will be applied in residential shower faucets where precise temperature control is most desired.

Wilfred Sorensen of Kingston, Ontario, has been awarded a grant to test a new two-phase thermosiphon generally referred to as a "bubble pump". The initial use for this pump is to use solar energy to circulate water to a residential solar domestic hot water heater.



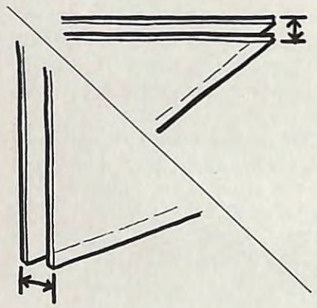
New Direct Vent Fireplace Standards

The Canadian Gas Association (CGA) has implemented a new direct vent gas fireplace testing standard (CGA Interim Requirement #41) designed to prove the structural integrity of direct vent gas fireplaces in severe situations.

The most difficult test fills the fireplace and all vents (both inner and outer pipes) with an explosive mixture of gas (9-10% gas/air mixture) which is then ignited. If the venting is not damaged, the glass does not break and there is no other damage to the fireplace, the unit passes the test. This test duplicates the worst possible situation (it's what happened in several cases where the glass did shatter into the room).

The standard also includes an endurance test where the fireplace is burned continuously for over 100 hours, as well as new wind, rain and temperature tests on the vent terminations.

Skylight Glass spacing



What is the ideal spacing between glass panes in skylights? Vertical panes have been studied for some time. The U-values of vertically insulated glazing units and the optimum pane spacing are known as this is the standard window case, but not skylights.

To find out the effect that pane spacing in insulated glass units had on U-values in horizontal as opposed to vertical installations, a series of computer simulations were done. The effect of the angle of the glass and optimum pane spacing on centre-of-glass U-values were calculated, using the Window 3.1 computer program developed at Lawrence Berkeley Laboratories.

The calculated values are for centre-of-glass only (no account is given to frame type), and pane spacing in increments of 1 mm (from 1 to 20 mm air space).

Unit Types simulated were:

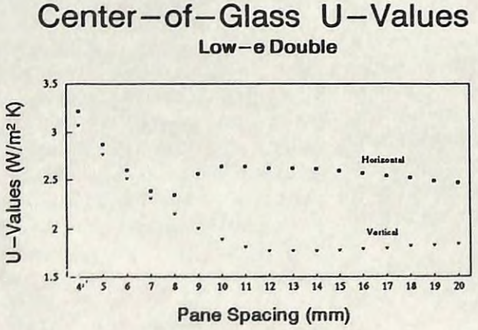
- Plain Double
- 1 low-e, double
- 1 low-e/argon double
- Plain triple
- 2 low-e triple
- 2 low-e/argon triple
- 1 Heat Mirror 55 triple

What was discovered?

A low-e double glazing with optimum pane spacing can have almost the same U-value as a low-e/argon double with non-optimum pane spacing. For small angles off the horizontal the unit can be considered to be horizontal, but as the angle increases it becomes more significant. The theoretical optimum spacing seems to be less than for vertical windows (at 8mm for horizontal compared to 12mm for vertical).

Before you rush off and use these results to determine the spacing between glass pane, you must realize that the Window 3.1 software does not take into account the effect of glass bowing under cold conditions. Glass bowing may change the spacing enough to radically alter the U-value in a horizontal or slightly inclined cases.

It must also be remembered that glazing units installed horizontaly or in a slightly inclined position generally are less energy efficient than when in a vertical position. The insulated glazing units also display a different response to pane spacing in horizontal or slightly inclined positions than in the vertical case.



***Roof Light Design Study, Phase 1: Centre of Glass U-Values** prepared by David Sargent of Edgetech I.G. Ltd. Ottawa, ON*

Are gas clothes dryers more efficient than electric dryers?

To get the answer a study was done for B.C. Gas. The object was to compare the efficiency and effectiveness of drying clothing using equivalently rated gas and electric dryers.

The test was done under laboratory conditions using 3 different "standard" clothing loads. Two Maytag dryers were used, both had identical heat and time controllers which were operated at the settings recommended by the manufacturer. Each was equipped with a factory installed thermostat.

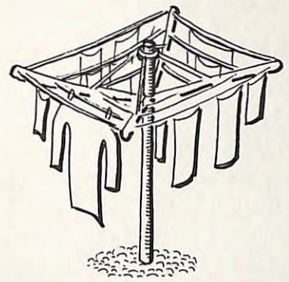
The drying time for each was 48 minutes per average load and ranged from 38 minutes for the white load to 62 minutes for the coloured load. Adding fabric softener had no effect on drying efficiency or drying time. The amount of water removed during a drying cycle was similar for each dryer at 58% of the dry weight. Lint accumulation was measured after each cycle.

Both dryers generated a static charge on the clothes but the amount of static charge on the electricity dried clothes was noticeably greater than in the gas fired dryer.

The gas dryer was 46% more cost efficient than the electric dryer (5.66 cents versus 10.5 cents per average load). Gas drying costs included both the consumption of gas (3.81 cents per load) and electricity required to rotate the dryer drum (1.85 cents per load). The costs were also adjusted for daily variations in fuel value.

Gas Dryer Cost and Installation

Gas dryers cost $50 - $60 more than electric dryers and if the gas lines are not available, installation costs could be $100 - $125 more than for an electric dryer. Depending on the frequency of use the savings gained by drying with gas could take 3 - 4 years to recover the cost difference.



If wash loads are modest, a drying rack in the house (in the basement or utility room) can be the answer to the common winter complaint of overly dry interiors found in the very cold parts of the country. Where humidification is a factor (and it may be even in tight energy efficient homes) then the drying rack could be used to provide that humidity. But if the frequency and quantity of washing is large (e.g. if a large family), then the dryer must be used or just too much moisture may be put into the house and that will create other problems.

Automatic dryers are now a standard feature in all homes. From a purely economic point of view, a solar clothes dryer is still much cheaper - whether it be the old fashioned clothes line or the higher - tech drying tree (that is easier to shield discreetly so that the neighbours don't see it).

Conservation Beats Fuel Switching

A recent report prepared by the Consumer Energy Council of America Research Foundation (CECA/RF) concluded that heating oil consumers who want to lower their energy bills will have a higher return on investment by investing in energy conservation, such as increasing insulation, reducing heat loss and purchasing high efficiency equipment than by switching to natural gas.

It was found that conservation generally yields 5 to 15% more than putting money in the bank, but fuel switching is a gamble on a price difference between oil and gas that is not likely to pay off. Since natural gas prices were decontrolled in the USA in 1985, the average price of oil has been less than the price of gas.

The report combines a price analysis with standard economic inputs and standard assumptions including: conservation investments ranging in cost from $500 to $2000 with energy savings and costs estimated on the basis of the most recent research; and opportunity cost (discount rate) of 3%.

Recent campaigns to convince consumers to switch fuels have frequently gone beyond simple consumer economics and give misleading advice to consumers about environmental considerations, national energy security and even international competitiveness. The correct answer regarding these matters is clear.

From an environmental point of view the best investment is to conserve a BTU of gas because far fewer pollutants are released into the atmosphere. From an economic and national energy perspective it is also better to conserve a BTU of oil than replace it with a BTU of gas because both fuels are depleting, non-renewable resources that are interchangeable for most uses. Conservation stretches the overall life of available resources and increases supply relative to demand.

The report titled **Oil, Gas, or...?**, is the third in a series of economic analyses of fuel switching and conservation. While it applies to the United States, but the principles apply equally in Canada.

*The report "**Oil, Gas, or..? Technical Support Document for a Consumer Decision Making Guide on Fuel Switching and Home Energy Conservation**," is available for $35 plus $2.50 shipping and handling from CECA/RF, 2000 L Street, NW, Suite 802, Washington, DC 20036.*

Business Excellence Award

Enermodal Engineering Limited is a finalist for the Canada Awards for Business Excellence in the Innovation category. Enermodal was selected for its work on energy-efficient window designs. With the financial assistance of CANMET they developed the FRAME computer program for analyzing heat transfer through window framing systems. FRAME is referenced as the only program for determining frame heat loss in the Canadian and U.S. window energy labelling standards. It is also being used throughout Europe, Japan and Australia. FRAME has been the key tool in rating windows for the Ontario Hydro window incentive program - the first program of its kind in North America.

Error correction:

The Degree day data in the Supplement to the National Building Code (1990) have some errors: the correct data for Duncan and Crofton (BC) is 3170 DDC.

Degree day data for any site should be considered as accurate to within ± 100 degree days (°C).

Autonomous House Award:

A Canadian Competition for Environmentally sensible zero energy homes

Do you live in a super energy efficient house? Have you built one? Do you know someone that does?

Scattered across Canada are many well-insulated, super energy efficient homes that take advantage of solar energy and incorporate other environmentally sensible measures such as water conservation and low impact materials. We never hear about these houses because they are usually built on a low budget without the glamour features that attract media attention.

Why a competition? We are facing major environmental problems caused in large part by over-use of inappropriate sources of energy. It is time to recognise and adopt some appropriate solutions.

The Solar Energy Society of Canada will showcase outstanding demonstration of an autonomous house each year to demonstrate the technologies that are working for families concerned about the future of the planet. Winners of the First Autonomous House Award will be announced in July 1992, at the Society's Annual Conference in Edmonton, Alberta.

What houses are eligible? Any house in Canada, new or old, single family, semi-detached, or row housing, with a proven performance of very low purchased energy consumption, together with other environmentally-sensible features. Judging criteria will not be limited to energy performance. Performance of the house will be verified by a third party.

Who can enter? Anyone who owns, lives in, or designed or built, an eligible house.

How to enter: *To obtain an entry form including more details on submission requirements, judging criteria, etc. send $3.00 for postage and handling to:*
SESCI, Suite 421, 301 Moodie Dr.,
Ottawa, Ont. K2H 9C4
Tel: (613)596-1096; FAX (613) 596-1120

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